Jurnal Sains Materi Indonesia
Indonesian Journal of Materials Science

Vol. 12, No. 2, Februari 2011, hal : 110 - 113
ISSN : 1411-1098

Akreditasi LIPI Nomor : 452/D/2010
Tanggal 6 Mei 2010

THE APPLICATION OF BENTONE AS NANOFILLER IN POLYPROPYLENE NANOCOMPOSITES

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ABSTRACT

THE APPLICATION OF BENTONE AS NANOFILLER IN POLYPROPYLENE NANOCOMPOSITES. For the last two decades, thermoplastic polymer based nanocomposites have been developed because of their superior properties. The benefits of these materials are light weight, high stiffness, and good resistance. With an addition of a small amount of filler, some properties improved significantly. This paper presents the tensile and flexural properties of a polypropylene with a dispersion of commercial Bentone clay in the matrix. Bentone polypropylene nanocomposites were successfully prepared by a melt intercalation method. The melting process was initiated by the addition of a modifier and an initiator. Bentone polypropylene nanocomposites with the variation of bentone contents were then analyzed. A pattern of clay morphology typically found in polypropylene based nanocomposites was observed using an X-Ray diffraction and a transmission electron microscope. These findings showed that an intercalated structure was formed. Furthermore, the value of tensile and flexural modulus as well as the value of tensile strength increased by an addition of 1 wt% bentone.

Key words : Bentone, Polypropylene nanocomposites, Tensile modulus, Flexural modulus

ABSTRAK

APLIKASI DARI *BENTONE* SEBAGAI *NANOFILLER* DALAM NANO KOMPOSIT POLIPROPILEN. Dalam dua dekade terakhir ini, nano komposit yang berbasis polimer termoplastik telah banyak dikembangkan karena keunggulan karakteristiknya. Keuntungan dari material ini diantaranya adalah ringan, kaku serta memiliki sifat ketahanan yang baik. Dengan ditambahkannya material pengisi (*filler*), beberapa sifatnya dapat ditingkatkan. Makalah ini memaparkan sifat kekuatan tarik dan kelenturan dari polipropilen dengan dispersi tanah liat *bentone* komersil dalam matriksnya. Nano komposit dari *bentone* polipropilen telah berhasil dibuat dengan menggunakan metode pelelehan dan interkalasi. Proses pelelehan dimulai dengan penambahan *modifier* dan *initiator*. Komposit dari *bentone* polipropilen dengan variasi konsentrasi dari *bentone* kemudian dianalisis. Pola morfologis tanah liat yang biasa ditemukan dalam nano komposit berbasis polipropilen dapat ditemukan dengan menggunakan difraksi sinar-X dan *TEM*. Temuan ini memperlihatkan bahwa struktur interkalasi telah terbentuk. Nilai dari modulus tarik dan lentur, serta nilai dari kekuatan tarik mengalami kenaikan dengan ditambahkannya 1% w/w *bentone*.

Kata kunci : *Bentone*, Nano komposit polipropilen, Modulus tarik, Modulus lentur

INTRODUCTION

For the last two decades, the organic inorganic nanocomposites have been widely studied and some of these potential materials have been used for a wide range of application. These materials, such as polymer layered silicate nanocomposites (PLSNs), have some benefits such as lighter weight, enhanced mechanical and thermal properties, as well as better fire resistance compared to the pristine polymers [1-4]. It is reported that a broad range of polymer have been used for these materials, such as epoxy, polyurethane, polyimide, polyester, polypropylene and polystyrene [5]. The role of nanofiller is important in the nano level of the materials. Being of 1 nm thickness clay silicate layers, the nanofiller is uniformly dispersed throughout the polymer matrix. Having a large surface ratio, the PLSNs show a significant change in mechanical and thermal properties. Only with less than 10 %nanofiller addition, these properties increase dramatically [6].

Polypropylene (PP) is one of the most widely used polymers since PP has a relatively simple structure and is easily recycled. Two methods have been developed to produce clay-PP nanocomposites, namely melt intercalation and intercalating polymerization [7]. One method to obtain a better mixing process during clay dispersion in a melt intercalation process is by the addition of a compatibilizer [6]. It has been studied that the compatiblizer promotes the formation of clay-PP nanocomposites. The presence of a compatibilizer, such as maleic anhydride (MA), reduces the viscosity of the PP during the clay dispersion. An optimum amount of MA can be added to the clay-PP mixture so that the PP molecules can easily enter the clay galleries or the clay particles can easily dispersed in the PP matrix.

Two different structures are formed when the clay is mixed with polymers, namely the intercalated and exfoliated structures. XRD is one effective method to characterize the nanocomposite structures. At least a peak is seen in the diffractogram of clay and from this peak, the (001) d-spacing can be identified. This peak will be shifted to the left as the d-spacing increases and this relates to the intercalated structure formation. When the peak disappears, an exfoliated structure may be formed. Moreover, Transmission Electron Microscope images also provide a better characterization since the clay layer separation can be observed. When the clay particles form aggregates in the matrix, the material obtained is identified as a composite.

In this study, a compatibilizer maleic anhydride and an initiator were added into the mixture of polypropylene (PP) and a commercial SD1 bentone to produce bentone-PP nanocomposites. The objectives of this research were to observe the structures of the materials using X-Ray Diffraction and Transmission Electron Microsope and to study the role of bentone in the tensile and flexural properties of the nanocomposites.

EXPERIMENTAL METHOD

The materials used in this experiment were polypropylene (PP) as the PLSNs matrix, maleic anhydride (MA) as the coupling agent, diphenylamine (DPA) as the initiator and a commercial SD1 bentone as the nanofiller.

A melt intercalation method was applied to synthesize the PLSNs. The PP, MA, DPA and Bentone were mixed using a rheomix machine at a temperature of 190 ^{o}C for 20 minutes with a 120 rpm rotor speed. The bentonite content varied of 1, 3, 5 and 7 wt%, while the weight percentage of MA was double of the bentonite percentage. The blending material was crushed and was then pressed using a compression moulding machine at a temperature of 180 ^{o}C and a pressure of 1 bar for 30 minutes.

An X-Ray Diffraction machine was used to observe the commercial bentone, the pristine PP and the PLSN materials.

The nanocomposites morphology structure was observed using a Transmission Electron Microscope after the specimens were prepared by a microtome. The tensile tests for the PLSNs materials were conducted according to ASTM D638 type IV, whereas the bending tests were followed ASTM 790.

RESULTS AND DISCUSSION

Figure 1 shows the results of XRD observation of the bentone, the pristine polypropylene (PP) and the bentone- PP nanocomposites with the variation of bentone loading. The first diffractogram has the diffraction angle of 2 θ = 4.54° equals to the (001) d-spacing of 1.98 nm. This peak is a characteristic peak of the SD1 bentone clay. The second diffractogram does not have any peak and this indicates a typical curve for non-crystalline polymers. There is no peak in the 1 wt%, 3 wt% and 7 wt%bentone-PP nanocomposite diffractograms. It is believed that exfoliated structure was formed.

However, an intercalated structure was formed in the 5 wt%bentone-PP nanocomposite. The peak at the diffraction angle of 2θ = 3.64° corresponds to the intercalated structure with a d-spacing of 2.41 nm. The XRD results indicated that formation of nanocomposite structures were achieved through the melt intercalation process.

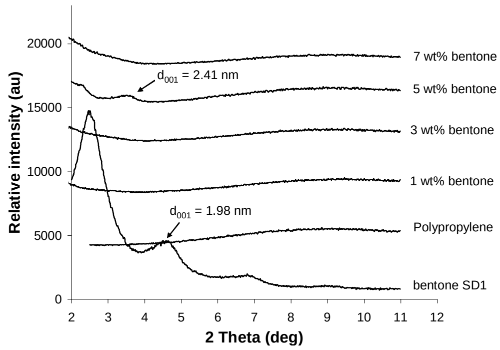

Figure 1. Diffractogram of bentone, polypropylene, and nanocomposites with different clay contents

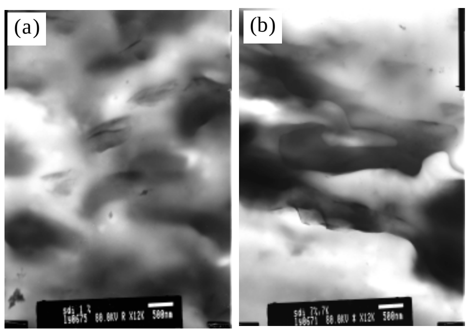

Figure 2. TEM images of (a). 1 wt%bentone-PP and (b). 7 wt%bentone-PP nanocomposites

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The TEM images of 1 wt% and 7 wt%bentone-PP nanocomposites are shown in Figure 2 (a) and Figure 2(b) respectively. The TEM image of 1 wt%bentone-PP nanocomposite is a typical image for intercalated nanocomposites where the clay layers can be seen in this image. While the TEM image of 7 wt%bentone-PP nanocomposite does not show any layer separation. This indicates that neither intercalated nor exfoliated structure was formed in this sampel. Even there is no XRD peak in the 7 wt%bentone-PP nanocomposite diffractogram which relates to an exfoliated structure, the TEM observation confirmed that the 7 wt%bentone-PP nanocomposite was a nanocomposite material with clay agglomerations. A similar image was obtained by Marchant and Jayaraman [8]. It is evidence for the 7 wt%bentone-PP systems that some amount of clay was dispersed in the matrix in which the PP penetrated into the clay galleries, however, some other amount of clay were identified as agglomerations.

Figure 3 demonstrates the tensile modulus and tensile strength of bentone-PP nanocomposites with a variety of bentone loadings. It is clear that the addition of 1wt% bentone in PP enhances the tensile properties. The values of both tensile modulus and tensile strength increases 20 %. It is also clear that the addition of 7 wt%bentone reduces the tensile strength by %. This reduction because the addition of high content of bentone addition produce brittle material [9]. From this result, it can be said that the effective amount of bentone in this nanocomposite systems to provide an enhanced tensile property is 1wt%.

Figure 4 shows the flexural modulus and flexural strength of bentone-PP nanocomposites with different bentone contents. It can be seen that an improvement in flexural modulus was achieved by the 1 wt%bentone-PP nanocomposite materials. While the flexural strength decreases as the clay content increases.

The presence of clay usually causes more brittle materials [9]. The flexural stress was not effectively transferred from the polymer matrix to the inorganic nano filler and this resulted the decreasing of flexural strength.

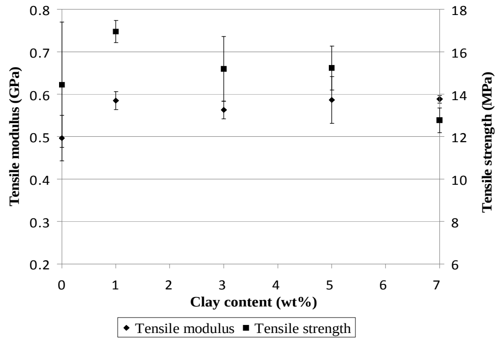

Figure 3. Tensile modulus and tensile strength of bentone-PP nanocomposites versus bentone contents.

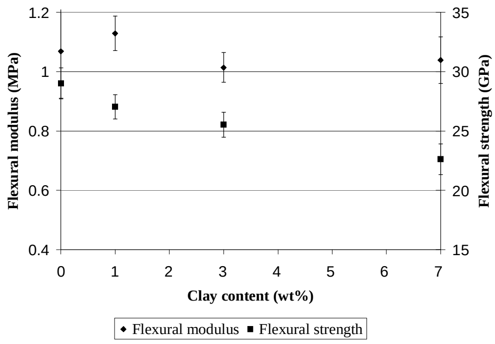

Figure 4. Flexural modulus and flexural strength of bentone-PP nanocomposites versus bentone contents.

Similar to the tensile test results, the most effective clay loading for flexural properties is 1 wt%.

From the structure observation and mechanical testing results, it can be said that 1wt% clay content is the most effective content for this bentone-PP nanocomposite material. The values of both tensile and flexural strength of these bentone-PP nanocomposite materials decrease significantly when the clay content was 7 wt%. Based on the TEM image of the 7 wt%bentone-PP nanocomposite, it is believed that the material obtained was composite, in which the bentone did not play as a nano filler. A further research on how the mechanism of high clay contents are dispersed in this bentone-PP systems should be carried out.

CONCLUSION

The addition of 1wt% bentone improves significantly the tensile modulus, tensile strength and flexural modulus of bentone-PP nanocomposite materials. Exfoliated and intercalated structure were found in the 1wt%, 3wt% and 5 wt%bentone-PP nanocomposite respectively. While the 7 wt%bentone-PP system was nanocomposite material with clay agglomerations in it.

ACKNOWLEDGMENT

This research was financially supported by the Incentive Research Program, Agency for Assessment and Application Technology. The authors thank to Nuning Aisyah and Henny Purwati from the Center of Material Technology, Agency for Assessment and Application Technology for their work contribution.

REFERENCES

[1]. M. GRASIA, G. VAN VLIET, S. JAIN, B.A.G. SCHRAUWEN, A.E. SARKISSOV, W. VAN ZYL and B. BOUKAMP, *Rev. Adv. Mater. Sci*., **6** (2004) 169-175

[2]. K. H. CHEN and S. M. YANG, *Journal of Appl. Sci*, **86** (2002) 414-421

[3]. Q.H. ZENG, A.B. YU, Q (MAX) LU and D.R. PAUL, *Journal of Nanosci Nanotech*, **5** (2005) 10

[4]. P. C. LE BARON, Z. WANG and T.J. PINNAVAIA, *Applied Clay Science*, **15** (1999) 11-29

[5]. M. KAWASUMI, N. HASEGAWA, M. KATO, A. USUKI and A. OKADA, *Macromolecules*, **30** (1997) 6333-6338

[6]. F. CHIU and P. CHU, *Journal of Polymer Res*., **13** (2006) 73-78

[7]. Y. ZHANG, J. LEE, J.M. RHEE and K.Y. RHEE, *Composites Sci and Tech*., **64** (2004) 1383-1389

[8]. D. MARCHANT and K. JAYARAMAN, *Ind. Eng. Chem. Res*., **41** (2001) 6402-6408

[9]. S.S. RAY and M. OKAMOTO, *Prog. Polym. Sci*., **28** (2003) 1539-1641